PETROLOGY OF THE 1951 KAW RIVER FLOOD DEPOSITS BETWEEN OGDEN AND MANHATTAN, KANSAS

by

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INTRODUCTION

The widespread realization that sediments have definite physical and chemical characteristics and may be analyzed by quantitative methods has been long delayed. However, with the growth of the oil industry and other economic needs, the value of laboratory study of sediments and sedimentary rocks has been recognized and the intensive study and development of sedimentary petrography has come forward to play an important part in geological science.

A close coordination between the field and laboratory work was for the purpose of obtaining the following objectives: careful selection and description of (1) the sample spots along the Kansas River, (2) a quantitative mineral analysis of the samples taken, (3) interpretation of the quantitative mineral analysis to correlate with other work done along the river, and (4) the general study of alluvial material other than those features mentioned.

The science of sedimentary petrography has made great strides in the last few years, but only those methods well established and generally familiar were used in the following material. Some limitations were encountered during the progress of the work, but all available sources were used for the purpose of the outlined objectives.

REVIEW OF LITERATURE

Since the time deVinci (18) made his notes in 1500 A. D. on sediments and tectonics, which resulted from his wonderment at finding marine fossils in bedded strata on mountain sides, the knowledge of sedimentation has grown slowly and intermittently.

In general, sedimentary deposits are considered to be the result of diastrophism, and the rate of sedimentation is dependent upon the supply of material and the rate of subsidence, both of which are controlled by the diastrophism or tectonics of the region involved.

Moore (11) divided continents into two tectonic elements: (A) the stable continental platform, and (B) the relatively mobile belts of geosynclines and geanticlines mainly peripheral to the platform. He divided the stable continental platform into negative and positive areas. The positive areas are the "shield" areas where the Pre-cambrian rocks are exposed. The negative areas are the Pre-cambrian rocks where they are concealed by thin sediments of sub-horizontal strata.

Pettijohn (12) called the sediments epicontinental and included the major sediments formed in epicontinental seas. The main processes were physical, chemical, and organic with sediments over a wide area, often highly variable. Because of shallow depths of the epicontinental seas only sediments in the litteral and pelagic zones are present and these areas are frequently subjected to slight elevations and subsidences "with resultant cyclical transgressions and regressions of the sea" (Pettijohn, 12).

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supplied depend upon terrain, topography, climatic conditions of the places of origin and transportation."

The channel sediments depend on physical deposition and range from gravel to clay, while the flood plain sediments ranged from clay to sand with occasional gravel. Sediments transported by traction are deposited in direct ratio to the decrease in competency and capacity, occasionally by a decrease in velocity of currents (Twenhofel, 21).

Raeburn and Milner, quoted from the 1923 Webster Dictionary (23), gave the following definitions of alluvium and alluvial: "alluvium - a deposit of earth, sand or other material made by the ordinary mechanical action of running waters" and "alluvial - pertaining to or contained in or composed of alluvium; relating to the deposits made by flowing water, washed away from one place and deposited in another."

Harned (5) considered the Kansas River alluvium to be mixed to a high degree with sediments of glacial origin, and the horizon of the soil was directly above the stratified alluvium. According to Harned's research, the alluvium contained all the minerals present in upland and terrace mantle with an admixture of rounded and angular grains caused by deposition of both glacial and stream-worked material. "The Smokey Hill and Republican alluvium shows a considerably smaller grade size than does the Kaw alluvium, indicating that the Kaw River has not been entirely dependent upon these streams for its source of sediment."

Rittenhouse (13) gave four reasons for the size distribution of heavy minerals in fluvial deposits as "(A) its relative availability in each size gradient in stream's load, (B) its equivalent hydraulic size, (C) the hydraulic conditions at the time and place of deposition and (D) some factor or factors now unknown."

Glacial material along the Kansas River and its northern tributaries was considered to have been redeposited continuously from the Kansas glacial age to recent by floods and erosion. Frye and Swineford (3) of Kansas thought "the prominent, high, deeply dissected terrace along the Kansas River Valley to be composed of Kansas glacial outwash classifiable as Meade formation. Large and coarse-grained sediments make for greater variations in thickness and limited distribution, while fine-grained sediments are considered to have had a larger areal extent with a more uniform thickness (Twenhofel, 21; Pettijohn, 12).

"The basic principles underlying the techniques of differentiating or correlating strata by means of their stable mineral components are essentially those fundamental to the science of geology" (Milner, 10). According to Milner, these principles were incorporated in the idea of the geographical cycle and geological interpretation. The geographic cycle presents the concept of "terrestial uplift of a base-levelled or peneplaned region; consequent reanimation of the forces of denudation; their slow operation in wearing down this newly-formed land surface; and the persistence of these forces until a new base level is once more attained."

Now if the parent rock was characteristic in mineral composition throughout the cycle of erosion, then it follows that a sediment will be equally characteristic in composition and the sediments formed by change of stable accessory minerals furnish a criterion for the subdivision of the material (Milner, 10). Therefore, it follows that to have any value in correlation, the heavy minerals of sediments need to have a restricted range in space and time.

If the samples are collected in vertical sequence, they are related to time and may have correlation value. "If the variations are observed in synchronous samples they are related to place, and may be called spatial variations. The change (decrease or increase) in percentages of a given mineral from place to place may be termed a mineral gradient" (Krumbein and Pettijohn, 7).

The three causes of mineral changes along a river considered by Krumbein and Pettijohn (7) are (A) contamination, (B) selective abrasion, (C) selective transportation. Contamination is caused by increase or decrease in percentage of certain minerals from the addition of new material at the junction of two streams, from areas with different petrographic character. The percentages of some minerals may be depressed while other minerals common to both sediments will be augmented.

Flood palin contamination in any stream depends on two factors: "(A) the amount of sediment added by bank cutting or channel scour in comparison with the amount of sediment in transit and (B) the amount and kinds of heavy minerals in the eroded and transit sands" (Rittenhouse, 13).

The mineral composition of a stream depends upon the amount, size, and kind of minerals in the source rocks; the manner in which the source rocks disintegrate during transportation; or the absolute and relative rates of transportation of different minerals and different sizes of minerals; and on hydraulic condition that occurs at the place and time of deposition (Rittenhouse, 13). In any case, "the interaction of all the factors involved results in the maintenance of a nearly uniform mineral composition excepting for local differences resulting from variations in grain size and degree of sorting" (Russell, 16).

In Nebraska, the units called Grand Island formation and Sappa formation corresponded to the Meade formation in Kansas. The Iowa Survey correlated the Sappa, Pearlette ash, Crete sand, and Loveland formation as the Yarmouth age. Some differences in age of the Pearlette ash was noted, however, its general time relationship was established as either the base of the Loveland formation or the upper part of the Meade formation. But according to the Nebraska Survey (Condra, et al., 13), the Crete-Loveland cycle of erosion and valley-filling started after the ash was deposited. "The gumbotil, peat, and soils on the Nebraskan and Kansan tills, and the soils on the Aftonian-Fullerton, Kansan-Sappa, Loveland, and Peoria formation are good horizon markers where they occur; i.e., were not removed by erosion, and the Pearlette volcanic ash seems to be the best time marker in Pleistocene of Nebraska" (Condra, 1).

Later Pleistocene material was restricted to the principal valley such as the Blue, with the Solomon, Saline, and Smokey Hill carrying no late Pleistocene outwash. One tributary of the Kaw, the Republican River, was affected (Swineford, 19) and "a few intermediate terrace remnants along middle reaches of the Kansas River valley may be Crete" (Frye and Swineford, 3).

Thickness of sediments may have ranged from thin to extremely thick, however, thickness is not always a measure of the rate of deposition. A thin layer of sediment in one place may correspond to a thick layer of sediment at another place. Sedimentation is rarely continuous and uniform but varies with environments of deposition, seasonal control, character of composing sediments, and numerous minor factors.

According to Twenhofel (21) and Grout (4) there were five classes of sediments: "terrigenous, organic, volcanic, cosmic or metoric, and magmatic." Of the several listed previously, only two include the scope of the material necessary for review, the elastic materials which were ejected by volcanoes, and the terrigenous sediments which resulted from decomposition of the rocks on the earth's surface.

"The elastic materials ejected by volcanoes are considered sediments when deposited from the atmosphere, if they have cooled sufficiently so as not to cohere" (Pettijohn, 12). The larger materials called lappilli, cinders and bombs, are deposited near the source. The ash or glass which forms curious curved spicule-like forms termed shards (Pettijohn, 12), may be blown into the upper atmosphere and carried great distances from the original source (Grout, 4). Large ash beds are found in the states of Kansas and Nebraska far removed from volcanoes (Twenhofel, 21). Ash falling in marine water may be altered to bentonite. In a few cases bentonite has formed on slopes of extinct volcanoes without the apparent help of sea water (Walstrom, 22).

"Terrigenous sediments result from the destruction of rocks on the surface and in the outer parts of the earth's crust" (Twenhofel, 21). The rocks affected by the destructive forces are igneous, sedimentary, and metamorphic rocks. Sediments vary with the material destroyed, and the manner of destruction, "the environment conditions of the places of production, and the distances and duration of transportation" (Twenhofel, 21).

> When heavy minerals are liberated by weathering of their parent rock, resistant species show relative concentrations, and less resistant species show decrease in relative abundance or disappear completely. The change in relative abundance of various minerals from fresh rock to the weathered products is a measure of their comparative resistance to weathering (Dryden and Dryden, 2).

The minerals of sediments may be divided into two groups. The first group originates from a foreign source and have been transported to the site of deposition. The origin of this group may be from sedimentary, igneous, or metamorphic rocks and the minerals are called detrital or allogenic. The second group of minerals is generated at the place found and is called authigenic (Pettijohn, 12; Twenhofel, 21).

The allogenic minerals may sometimes be traced to their point of origin. They aid in the study of the environmental conditions which released them from their parent rock. Allogenic minerals are also a great aid for the purposes of correlation, and the study of ancient geography, climate, and zoning of sedimentary sequences (Twenhofel, 21).

Russell (16) pointed out that the "persistent detrital minerals in rivers appeared to be those that are more resistant to chemical processes than to mechanical action."

> The authigenic minerals may give some evidence of the conditions of deposition of the sediments of which they form a part and certainly of the environmental conditions that led to the development of these minerals. Unfortunately knowledge of the developmental conditions of authigenic minerals leaves much to be desired (Twenhofel, 21).

Twenhofel (21) and Pettijohn (12) have slightly different classifications of minerals; however, they agree on the stable or primary minerals and the precipitated or authigenic minerals.

Some of the most common primary minerals are hornblende, garnet, epidote, chorite, diopside, apatite, augite, andalusite, hypersthene, ilmenite, kyanite, rutile, sphene, leucoxene, muscovite, enstatite, magnetite, staurolite, tourmaline, zoisite, zircon, feldspars, and quartz (Twenhofel, 21; Pettijohn, 12).

The most abundant mineral of arenaceous sediments is quartz, followed by feldspars (Pettijohn, 12; Twenhofel, 21). Pettijohn (12) considers muscovite, biotite, hornblende, augite, and hypersthene as some of the most common of the heavy minerals, but he also considers zircon, rutile, tourmaline, and apatite as the most stable minerals with garnet, staurolite, and kyanite as relatively unstable. Milner (10) did not agree that apatite was a stable mineral. Grout (4) also considered some of the most common residuals to be zircon, tourmaline, magnetite, and apatite.

A total of 1,500 different minerals is known to science. It is surprising in some respects how many species fail to survive weathering and transportation. A study of the records of alluvial minerals all over the world shows the restrictions of mineral species in sediments caused by destructive chemical and mechanical forces (Milner, 10).

> Most heavy-mineral investigations have one or more of the following objectives: (A) to describe the mineral composition of a particular deposit; (B) to establish the similarity or dissimilarity of samples, generally for the purpose of geologic correlation; (C) to determine the change in mineral composition within a series of related samples so that factors related to the occurrence of heavy minerals may be discovered and evaluated; (D) to locate the sources or to evaluate the relative importance of various sources of a deposit; (E) to provide data from which the past history of a deposit may be interpreted; and (F) to find and aid in the exploitation of economically useful minerals (Rittenhouse, 13).

Outline for Identification of Minerals (Rogers and Kerr, 15)

- Description of mineral to be identified
- Associated minerals
    - Color (if opaque)
    - Transparent
        - Properties, if transparent
            - Color
            - Pleochroism
            - Shape or form
            - Cleavage
            - Indices of refraction
            - Isotropic or anisotropic
            - If anisotropic
                - Birefringence or double refraction
                - Twinning (if present)
                - Elongation (if any)
            - Optical classification
                - Uniaxial
                    - Positive or negative
                    - 2V (or 2E)
                    - Dispersion
                - Optical orientation

Nearly every author agreed on the outline of procedure which has to be used for the processing of common sediments for study. Briefly, the steps recommended were the following: (A) quarter the sample, (B) weigh out a portion, (C) treat it with weak acid, (D) wash (decant), (E) screen the material, (F) separate with bromoform, (G) identify the minerals in oils or make permanent mounts in air or balsam, (H) diagram the results (Milner, 10; Twenhofel and Tyler, 20; Twenhofel, 21; Krumbein and Pettijohn, 7; Grout, 4; and Pettijohn, 12).

In an attempt to get more material for study, Krynine's (9) classification of quartz was used in addition to the identification of the quartz, because the quartz was the dominant mineral of all samples.

FIELD AND LABORATORY METHODS

Field Methods

Work in the field covered an area of approximately 15 miles along the Kansas River. Sample sites were from 100 yards to several miles apart, depending upon the river deposits.

Equipment. The equipment used in the field consisted of a measuring tape, sample bags, hand trowel, and a field book.

Sites. Forty sample sites were made along the Kansas River from the Big Blue River west to the town of Ogden. Each site was chosen only after good evidence was found that the deposit to be sampled was from the 1951 flood. The time of the sampling and location of the deposits controlled the selecting of samples.

Location. Samples collected in the Manhattan area during and soon after the flood were sampled at two depths. Other samples taken as late as 1953 were sampled only in the near surface, because the depth of the deposit was uncertain and the age of deeper samples would have been doubtful.

Accessibility. Accessibility was no factor of importance except for loss of time in collecting samples, as all samples had to be carried out to a road, and only so many could be carried at one time.

Vertical Depth. The vertical depth was determined by the length of time that had elapsed since the flood. In 1951 two sample depths were taken at most sites, but at all later dates only one was taken. This was due to the doubtful age of the deposits at depth.

Measurements. Measurements were made from ground surface down to three feet, and the measurements were made in tenths of feet.

Samples. Each sample was carefully labeled and marked according to location. Also the mark was duplicated on each sample at least twice. Such precautions were used to prevent loss of identification and mistaken identification.

Limits. The only limiting factor was the positive identification of the 1951 flood sediments in the years of 1952 and 1953.

Laboratory Methods

In general, the methods used in the laboratory were processes which have been used over a long period of time for the treatment

EXPLANATION OF PLATE I

Sample Site Locations

			Page*
Ogden Area			
	Sample 1.	NE$\frac{1}{4}$ SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 7, T. 11 S., R. 7 E.	24
	Sample 2.	NW$\frac{1}{4}$ SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 7, T. 11 S., R. 7 E.	24
	Sample 3.	NE$\frac{1}{4}$ NW$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	24
	Sample 4.	NE$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	25
	Sample 5.	SE$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	25
	Sample 6.	" " " " " " " " " " "	25
	Sample 7.	NE$\frac{1}{4}$ SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	26
	Sample 8.	SW$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	26
	Sample 9.	SW$\frac{1}{4}$ SW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	26
	Sample 10.	" " " " " " " " " " "	27
	Sample 11.	NW$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 8, T. 11 S., R. 7 E.	27
	Sample 12.	" " " " " " " " " " "	27
Hunter's Island Area			
	Sample 13.	NW$\frac{1}{4}$ NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 30, T. 10 S., R. 8 E.	31
	Sample 14.	SW$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 31, T. 10 S., R. 8 E.	31
	Sample 15.	SW$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 31, T. 10 S., R. 8 E.	31
	Sample 16.	NE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 31, T. 10 S., R. 8 E.	32
	Sample 19.	NE$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 31, T. 10 S., R. 8 E.	32
	Sample 29.	NE$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 36, T. 10 S., R. 7 E.	32
Wildcat Creek Area			
	Sample 20.	NE$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 13, T. 10 S., R. 7 E.	36
	Sample 21.	SE$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 13, T. 10 S., R. 7 E.	36
	Sample 22.	NE$\frac{1}{4}$ SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 13, T. 10 S., R. 7 E.	36
	Sample 23.	SE$\frac{1}{4}$ SE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 13, T. 10 S., R. 7 E.	37
	Sample 24.	SE$\frac{1}{4}$ NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 24, T. 10 S., R. 7 E.	37
	Sample 25.	SE$\frac{1}{4}$ NW$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 24, T. 10 S., R. 7 E.	37
	Sample 26.	SW$\frac{1}{4}$ NE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 24, T. 10 S., R. 7 E.	38

EXPLANATION OF PLATE I (concl.)

		Page*
Blue River and Manhattan Areas		
Sample 36.	SW¼ SW¼ SW¼ sec. 17, T. 10 S., R. 8 E.	41
Sample 27a,b.	SE¼ SE¼ SE¼ sec. 18, T. 10 S., R. 8 E.	42
Sample 28a,b.	SE¼ SE¼ NW¼ sec. 17, T. 10 S., R. 8 E.	43
Sample 30a,b.	NE¼ NE¼ SW¼ sec. 17, T. 10 S., R. 8 E.	44
Sample 31.	SE¼ SE¼ SE¼ sec. 5, T. 10 S., R. 8 E.	47
Sample 32.	NE¼ SE¼ NW¼ sec. 8, T. 10 S., R. 8 E.	48
Sample 33.	SE¼ NE¼ SE¼ sec. 8, T. 10 S., R. 8 E.	48
Sample 34.	NW¼ SW¼ SW¼ sec. 9, T. 10 S., R. 8 E.	48
Sample 35a,b.	SW¼ SW¼ SW¼ sec. 9, T. 10 S., R. 8 E.	49
Sample 17.	SW¼ NW¼ NW¼ sec. 20, T. 10 S., R. 8 E.	42
Sample 18.	SW¼ NW¼ NW¼ sec. 20, T. 10 S., R. 8 E.	43

* Detailed description for each plot can be found on the page listed for the sample area.

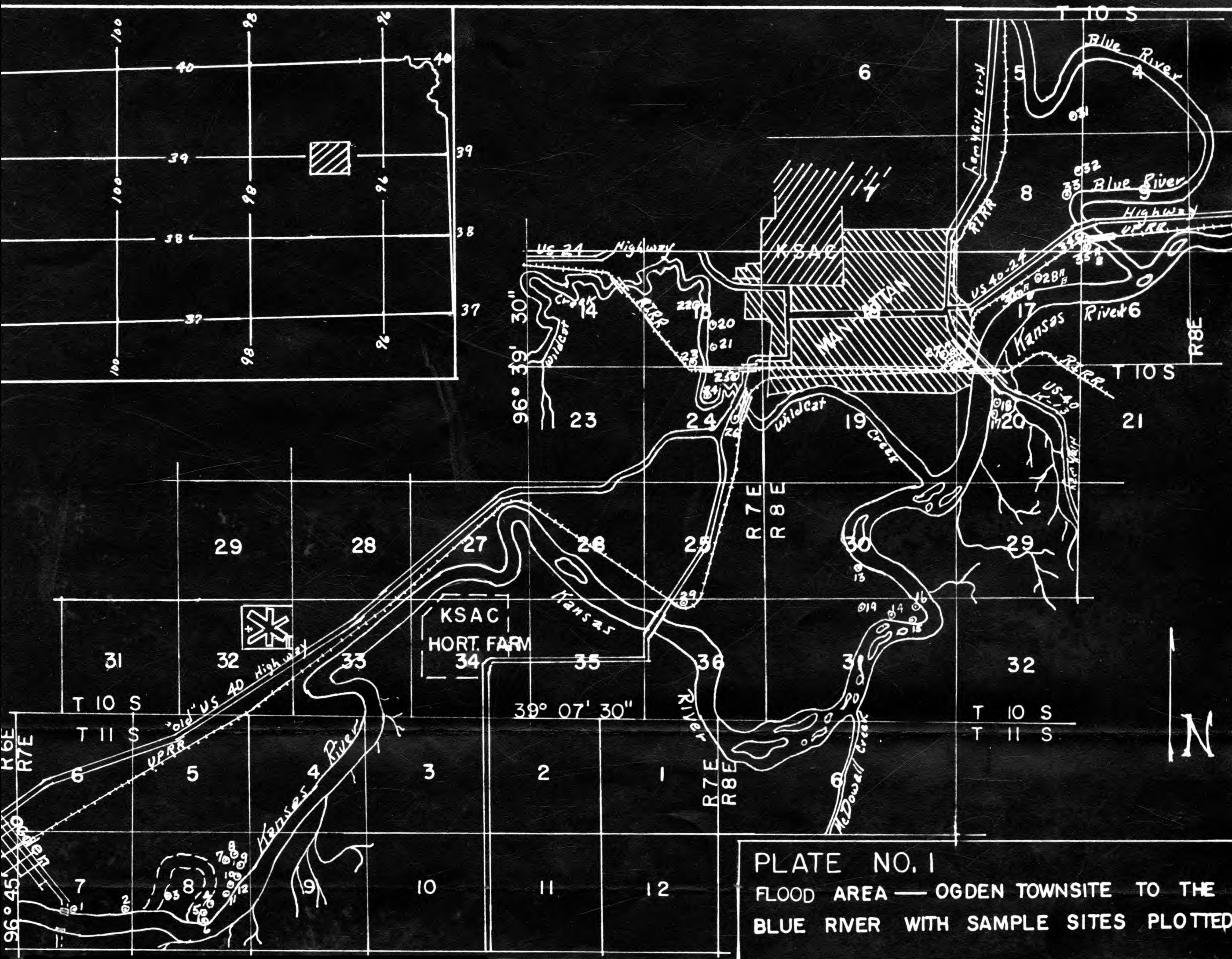

PLATE NO. I
FLOOD AREA — OGDEN TOWNSITE TO THE BLUE RIVER WITH SAMPLE SITES PLOTTED
KSAC
MANHATTAN
KSAC HORT. FARM
Kansas River
Blue River
Wildcat Creek
McDowell Creek
Ogden
"old" US 40 Highway
US 24 Highway
US 40-24
UPRR
T 10 S
T 11 S
R7E
R8E
39° 07' 30"
96° 39' 30"
96° 45'
N

of similar material.

The following steps were used with each sample:

Dry the raw sample
Quarter and weigh the sample
Disperse the sample by mechanical shaking
Boil in dilute HCl gently for five minutes
Wash the sample free of acid
Wet-sieve the sample
Oven-dry the sample
Dry-sieve the sample
Separate the heavy and light mineral fractions in bromoform
Filter off the mineral fractions and dry on filter paper
Prepare permanent slides
Make a mineralogical analysis of the slides prepared

Dry the Raw Sample. Each sample was dried about 10 hours in a drying oven to make sure that no moisture remained in the material. Although accurate weight and volume were not taken into account, all amounts of material used for each sample were kept rather constant and all samples were given the same treatment to keep the moisture level constant.

Quarter and Weigh the Sample. After each sample was dried, it was well mixed by stirring. The sample was then quartered and re-quartered until the amount of material wanted for separation remained. From the quartered material 100 grams was weighed out for the next step. If the sample appeared to be high in clay or coarse-grained sand, the amount used was 200 grams.

Disperse the Sample by Mechanical Shaking. The sample was placed in a 16-ounce bottle; 40 cubic centimeters of a liquid solution of sodium silicate (10 grams of sodium silicate to 400 cubic centimeters of distilled water) was added, and the bottle filled with water. The samples were then shaken for an hour and a half in the shaker. Since the material used was unconsolidated, a longer time was not necessary to produce complete dispersion.

Boil in Dilute HCl Gently for Five Minutes. The material was gently boiled in dilute HCl (10 drops of commercially pure HCl added to about 30 cubic centimeters of water) for a period of five minutes to remove all calcium carbonate and any coatings of iron oxide.

Wash the Sample Free of Acid. After the material had been boiled in acid, it was necessary to eliminate all the acid by washing. Any acid retained by the sample will cause it to ball-up, and poor separation of the grains will result in the bromoform treatment. Water was added to each sample, stirred, allowed to settle, and then the water was decanted. Usually four such rinses were sufficient for small samples, but as many as eight rinses were used on some of the larger ones.

Wet-sieve the Sample. The samples were wet-sieved after washing to retain the size material necessary for petrographic examination. The sieves used were the 120-mesh sieve and the 230-mesh sieve. All the material caught on the 230-mesh sieve was saved for final examination. If the original sample was extremely coarse or extremely fine, a larger raw sample was used in order to have a suitable amount captured on the 230-mesh sieve. The sample captured on this sieve had to be large enough in quantity for the heavy and light mineral separation in bromoform.

Oven-dry the Sample. Drying the sample was important, because in the bromoform separation for light and heavy minerals, films of water would cause cohesion and interfere with separation. Care was taken during this drying period to be absolutely positive the sample was dry, as moisture would cause cohesion of the grains in the sample. Six hours was the time used for drying the samples. Because fine particles were not all removed by wet-sieving and drying caused some lumping, a dry-sieving step was necessary immediately following the drying.

Dry-sieve the Sample. The sample was crushed with a spatula and sieved once again on a dry sieve. All material disintegrated by the acid passed through the 230-mesh sieve, and only the remainder was saved for the bromoform process.

Bromoform Separation for Light and Heavy Minerals. Bromoform had a specific gravity of approximately 2.89. All minerals with a specific gravity less than the bromoform floated. These include quartz, chalcedony, orthoclase, microcline, plagiclase, and volcanic ash. The heavy minerals had specific gravities higher than the bromoform and therefore sank. Some of the more important minerals in this group were magnetite, ilmenite, zircon, topaz, hornblende, epidote, muscovite, biotite, garnet, augite, tourmaline, rutile, and lamprobolite. The apparatus and reagents used for separation included three funnels, rubber tubins, pinch-cock, filter paper, bromoform, and alcohol. The procedure was as follows: The bromoform was poured in a funnel with a short hose and pinch-cock at the bottom. The sample was placed in the bromoform, and the natural separation due to the difference in specific gravity of the minerals took place. If the samples were large, the liquid was stirred several times. The liquid was allowed to come to rest, and the heavy minerals which had settled to the bottom were drawn off onto a filter paper. The light minerals floated and were washed off onto another filter paper. The pure bromoform was saved for re-use, and the separated samples were washed free of bromoform with alcohol. The alcohol and bromoform were also saved, as they may be separated with water and the bromoform used again.

Minerals Dried on Filter Paper. The specimens, after separation and washing with alcohol, were then placed in the oven for drying. The drying step was to prepare the material for making permanent slides of the samples. Any moisture on the minerals may cause incomplete coating on the surfaces of the minerals by the Canada balsam.

Permanent Slides Prepared. After the samples had been dried, they were ready for the next step - the making of Canada balsam slides for petrographic study of the samples. The glass slides were placed on a heater, and the balsam was cooked on the slides until deemed ready for the sample. The sample was taken from the filter paper with a nonmagnetic spatula and scattered on the cooked balsam. The minerals were stirred into the balsam to prevent air bubbles from forming around the minerals. A cover slide was carefully placed over the area containing the minerals.

Each slide was labeled according to the location. The labeled slides could now be stored and re-examined at any future date.

Mineralogical Analysis of Slides. A quantitative count of the particles on the slides was made to determine the percentage of minerals in each slide. To the rotating stage of the petrographic microscope was attached a mechanical stage, which by means of two thumb screws permitted movements of a slide in two directions at right angles to one another. The mechanical stage made possible a reliable count of the minerals present without fear of counting some minerals twice, or of skipping the less noticeable minerals.

GENERAL DESCRIPTIONS OF SAMPLE AREAS AND PLOTS

The general region of this work was along the Kaw River Valley from the town of Ogden, Kansas, eastward to the Blue River. Samples were taken from five areas. (1) The Ogden area, named for the town of Ogden, included the area of the Kaw River Valley from Ogden eastward for about a mile. (2) The Hunter's Island area extended from the mouth of Wild Cat Creek west along the bank of the Kaw River approximately two miles. (3) The Wild Cat Creek area extended south and east on both sides of Wild Cat Creek from Sunset Park in Manhattan around to U. S. Highway 40. (4) The Manhattan area was restricted to the neighborhood of the Kaw River at Manhattan. (5) The Blue River area extended from the east side of Manhattan to the Blue River along the north bank of the Kaw River.

All but three of the samples collected were used. Two of the discarded samples were very high in silt and the other was an exceedingly large placer deposit. The percentage for several minerals in these samples was sufficiently abnormal to give a false picture of the average found in the local areas where these samples were taken. Silt-highs and placers are discussed further on page 61.

To obtain a percentage for this work, a mineral count was taken from the slides made. The total of all minerals counted was divided into the count for each mineral to obtain this percentage. This was done for both the heavy and the light fractions of each slide.

Most of the data obtained from Seiler and Harned had already been worked out into the percentages wanted and are listed in their publications. In other cases the material wanted had to be computed to percentage by the same method used in this work.

In this work quartz was found to make up as much as two-thirds of the light fraction. Because of this, an attempt was made to identify each kind of quartz and establish its own percentage in the light fraction. The percentage of quartz in the light fraction is the total of the percentages of each kind of quartz.

The kinds of quartz in sediments are as follows:

I. Normal Igneous Quartz. No strain shadows, few inclusions or at most places of liquid and gas inclusions and microlites of zircon and biotite.

II. End-phase Quartz. Formed under slight pressure of the restmagma state and with weak strain shadows and abundant inclusions of tourmaline and rutile.

III. Hydrothermal Quartz. Marked by inclusions of green, vermicular chlorite.

IV. Modified Igneous Quartz. With strongly marked strain shadows.

V. Quartzite Fragments and Lensoid Grains. Marked by strong undulose extinction, crenulated borders and inclusions of sillimanite and kyanite.

VI. Quartzitic Aggregates.

VII. Schistose Quartz. Elongated usually parallel to the c axis.

VIII. Authigenic or Secondary Quartz. As overgrowths on detrital grains.

These eight kinds of quartz grains were found in the "Third Bradford Sand" by Krynine (9). They are designated in the work of this thesis by Roman Numerals and are listed this way in the tables and table discussions of each area of this work.

The Ogden Area

The samples of the Ogden area are located over a distance of a mile and a half along the north side of the Kaw River from the Ogden bridge eastward. The collecting of samples in this area was made in February 1953 from surface flood deposits.

Nearly all the samples appeared to contain fine material with no extremely coarse sand apparent. The light color was due to the large quartz content as shown by the mineral analysis.

These samples were taken a year and a half after the flood that deposited them, and the true depth of deposits was doubtful after a few feet. For this reason these samples were all taken from depths of six inches to one foot.

Quartz (72 to 62 percent) was the dominant mineral in the light fraction. Chalcedony varied from 13 to 22 percent, feldspars varied from 8 to 16 percent, and volcanic ash varied from

0 to 2 percent. The heavy minerals showed: the opaques 49 to 8 percent, amphiboles and pyroxenes 62 to 22 percent, muscovite and biotite 2 to 13 percent, epidote 2 to 6 percent, monazite 2 to 11 percent, zircon 7 to 22 percent, garnet 3 to 9 percent, and others 1 to 4 percent.

The first sample was about 10 yards east of the north footing of the Ogden bridge. The sample (1) was fine-grained and light-colored due to an excess of quartz. The percentages of each variety of quartz were as follows: I-30, II-7, III-8, IV-12, V-1, VI-5, VII-Q, and VIII-1, giving a quartz total of 64 percent. Chalcedony had 22 percent, orthoclase 8 percent, microcline 4 percent, plagoclase 1 percent, and ash 1 percent. The heavy fraction had opaques 12 percent, amphiboles and pyroxenes 58 percent, micas 4 percent, zircon 16 percent, monazite 2 percent, garnet 3 percent, and others 2 percent.

Sample (2) was collected one-half mile east of sample (1) from a dune. The texture and color were about average. Quartz had I-34 percent, II-6 percent, III-7 percent, IV-12 percent, V-1 percent, VI-3 percent, and VII and VIII-0 per cent, giving a total of 63 percent of quartz. Chalcedony had 21 percent, orthoclase 6 percent, microcline 1 percent, feldspars 6 percent, and ash 2 percent. The heavy minerals showed opaques 16 percent, amphiboles and pyroxenes 50 percent, zircon 13 percent, mica 8 percent, epidote 4 percent, monazite 2 percent, garnet 5 percent, and others 2 percent.

Sample (3) had fine texture and light color. The quartz showed I-29 percent, II-6 percent, III-9 percent, IV-13 percent, V-1 percent, VI-3 percent, VII-1 percent, and VIII-0 percent, giving a total of 62 percent for quartz. Chalcedony had 21 percent, orthoclase 7 percent, microcline 1 percent, plagaclase 5 percent, and ash 0 percent. The heavy fraction had 8 percent opaques, amphiboles and pyroxenes 62 percent, zircon 15 percent, epidote 1 percent, monazite 2 percent, mica 8 percent, garnet 2 percent, and others 2 percent.

In sample (4) a fine texture was found and the color was light. The quartz showed I-34 percent, II-7 percent, III-9 percent, IV-11 percent, V-0 percent, VI-4 percent, VII-0 percent, and VIII-1 percent, giving a total of 66 percent for quartz. Chalcedony had 15 percent, orthoclase 7 percent, microcline 3 percent, plagaclase 8 percent, and ash - percent. The heavies showed opaques 22 percent, amphiboles and pyroxenes 37 percent, zircon 18 percent, micas 5 percent, epidote 5 percent, monazite 2 percent, garnet 9 percent, and others 2 percent.

In sample (5) the texture was medium fine and the color was darker than average. The quartz had I-35 percent, II-9 percent, III-8 percent, IV-9 percent, V-1 percent, VI-5 percent, VII and VIII-0 percent, giving a total of 67 percent for quartz. Chalcedony had 17 percent, orthoclase 7 percent, microcline 1 percent, plagaclase 7 percent, and ash 0 percent. The heavy fraction showed opaques 34 percent, mica 7 percent, amphiboles and pyroxenes 27 percent, zircon 11 percent, epidote 11 percent, monazite 4 percent, garnet 5 percent, and others 1 percent.

In sample (6) the texture was fine, but the color was darker than the average. Quartz had I-34 percent, II-7 percent, III-8 percent, IV-12 percent, V-1 percent, VI-3 percent, VII and VIII-0 percent, giving a total of 65 percent for quartz. Chalcedony had 13 percent, orthoclase 8 percent, microcline 3 percent, plagaclase 8 percent, and ash 1 percent. The heavies showed opaques 34 percent, amphiboles and pyroxenes 38 percent, micas 4 percent, zircon 12 percent, epidote 2 percent, monazite 2 percent, garnet 6 percent, and others 2 percent.

Sample (7) had medium texture and a dark color in relation to the other samples. The quartz had I-35 percent, II-8 percent, III-8 percent, IV-3 percent, V-0 percent, VI-3 percent, VII and VIII-0 percent, giving a total of 71 percent for quartz. Chalcedony showed 17 percent, orthoclase 4 percent, microcline 2 percent, plagaclase 6 percent, and ash 0 percent. The heavy fraction showed opaques 19 percent, amphiboles and pyroxenes 38 percent, mica 13 percent, zircon 16 percent, epidote 4 percent, monazite 3 percent, garnet 4 percent, and others 3 percent.

Sample (8) had a dark color and a medium fine texture. Quartz had I-36 percent, II-7 percent, III-10 percent, IV-13 percent, V-0 percent, VI-1 percent, VII and VIII-0 percent, giving a total of 67 percent for quartz. Chalcedony showed 20 percent, orthoclase 4 percent, microcline 2 percent, plagaclase 5 percent, and ash 0 percent. The heavies showed opaques 38 percent, amphiboles and pyroxenes 25 percent, micas 7 percent, zircon 7 percent, epidote 8 percent, monazite 3 percent, garnet 8 percent, and others 4 percent.

In sample (9) the texture was fine and the color was average. Quartz had I-31 percent, II-8 percent, III-9 percent, IV-15 percent, V-0 percent, VI-3 percent, VII-0 percent, VIII-1 percent, giving a total of 67 percent for quartz. Chalcedony had 15 percent, orthoclase 5 percent, microcline 3 percent, plagaclase 8 percent, and ash 1 percent. The heavies had opaques 30 percent, micas 4 percent, amphiboles and pyroxenes 32 percent, zircon 14 percent, epidote 7 percent, monazite 4 percent, garnet 6 percent, and others 4 percent.

Sample (10) had fine texture and light color. Quartz had I-30 percent, II-5 percent, III-11 percent, IV-19 percent, V-1 percent, VI-2 percent, VII-1 percent, and VIII-0 percent, giving a total of 69 percent for quartz. Chalcedony showed 15 percent, orthoclase 5 percent, microcline 3 percent, plagaclase 7 percent, and ash 1 percent. The heavies showed opaques 22 percent, amphiboles and pyroxenes 46 percent, micas 5 percent, and others 4 percent.

Sample (11) was fine-textured, but the color was very dark. Quartz showed I-34 percent, II-9 percent, III-5 percent, IV-14 percent, V-1 percent, VI-2 percent, and VII and VIII-0 percent, giving a total of 65 percent for quartz. Chalcedony had 18 percent, orthoclase 5 percent, microcline 3 percent, plagaclase 7 percent, and ash 0 percent. The heavies had opaques 44 percent, amphiboles and pyroxenes 22 percent, micas 6 percent, zircon 9 percent, epidote 6 percent, monazite 3 percent, garnet 5 percent, and others 5 percent.

In sample (12) the texture was medium-coarse in relation to the average sample taken. Quartz had I-37 percent, II-7 percent, III-12 percent, IV-11 percent, V-1 percent, VI-3 percent, VII-0 percent, and VIII-1 percent, giving a total of 72 percent for quartz. Chalcedony had 15 percent, orthoclase 7 percent, microcline 2 percent, plagaclase 4 percent, and ash 0 percent. The heavies had opaques 49 percent, amphiboles and pyroxenes 22 percent, zircon 10 percent, micas 2 percent, epidote 6 percent, monazite 3 percent, garnet 6 percent, and others 2 percent.

A total of the light mineral fraction in this table showed quartz to have I-33 percent, II-7 percent, III-8 percent, IV-13 percent, V-1 percent, VI-3 percent, and VII and VIII-1 percent, giving a total of 66 percent for quartz. Chalcedony had 16 percent, orthoclase had 6 percent, plagaclase had 6 percent, microcline had 2 percent, and was 0.5 percent ash. The heavy fraction had 28 percent opaques, amphiboles and pyroxenes 39 percent, micas 6 percent, zircon 13 percent, epidote 5 percent, monazite 3 percent, and others 6 percent.

The Hunter's Island Area

The samples of the Hunter's Island area were located over a distance of two miles along the north side of the Kansas River east of the bridge. The samples were light-colored and quite fine-textured.

All but one of the samples were taken in September of 1952 and were taken at depths of six inches to one foot. The remaining sample was taken in September of 1951 and was taken at a depth of 18 inches.

Quartz (75 to 62 percent) was the largest amount of the light fraction. Chalcedony had 11 to 25 percent, feldspars 11 to

Table 1. Ogden area: Quantitative mineral analysis.

Minerals	1	2	3	4	5	6	7	8	9	10	11	12	Average
	Sample numbers												
Heavy fraction													
Hematite	0	0	0	0	0	0	0	0	1	0	1	0	0.2
Magnetite	6	8	4	14	23	22	8	24	19	12	31	33	17.0
Ilmenite	6	8	4	8	11	12	11	14	10	10	13	16	10.3
Zircon	16	13	15	18	11	12	16	7	14	14	9	10	13.0
Topaz	1	0	1	0	0	0	0	1	1	1	1	0	0.5
Hornblende	58	50	62	37	27	38	38	25	32	46	22	22	38.1
Epidote	3	4	1	5	11	2	4	8	7	3	6	6	5.0
Muscovite	3	6	5	4	6	4	12	7	4	5	6	2	5.3
Biotite	1	2	3	1	1	0	1	0	0	0	0	0	0.8
Garnet	3	5	2	9	5	6	4	8	6	4	5	6	5.3
Tourmaline	0	0	0	1	0	1	1	0	1	1	1	1	0.6
Rutile	0	1	0	0	0	0	0	0	0	1	0	0	0.2
Monazite	2	2	2	2	4	2	3	3	4	3	3	3	2.8
Tremolite-Actinlite	1	1	1	1	1	1	2	3	1	1	2	1	1.3
Light fraction													
Quartz	64	63	62	66	67	65	71	67	67	69	65	72	66.5
Chalcedony	22	21	21	15	17	13	17	20	15	15	18	15	15.8
Orthoclase	8	6	7	7	7	8	4	4	5	5	5	7	6.0
Plagaclase	4	6	5	8	7	8	6	5	8	7	7	4	6.3
Microcline	1	1	1	3	1	3	2	2	3	3	3	2	2.0
Ash	1	2	0	0	0	1	0	0	1	1	0	0	0.5

Table 1 (concl.).

Minerals	Sample numbers												Average
	1	2	3	4	5	6	7	8	9	10	11	12	
						Classification of quartz							
I	30	34	29	34	35	34	35	36	31	30	34	37	33.3
II	7	6	6	7	9	7	8	7	8	5	9	7	7.2
III	8	7	9	9	8	8	8	10	9	11	5	12	8.0
IV	12	12	13	11	9	12	17	13	15	19	14	11	13.2
V	1	1	1	0	1	1	0	0	0	1	1	1	0.6
VI	5	3	3	4	5	3	3	1	3	2	2	3	3.0
VII	0	0	1	0	0	0	0	0	0	1	0	0	0.2
VIII	1	0	0	1	0	0	0	0	1	0	0	1	0.3
Total quartz	64	63	62	66	67	65	71	67	67	69	65	72	66.5

20 percent, and volcanic ash varied from 0 to 3 percent. The heavy minerals showed the opaques 6 to 58 percent, amphiboles and pyroxenes 20 to 48 percent, muscovite and biotite 2 to 41 percent, epidote 2 to 11 percent, monazite 1 to 10 percent, zircon 4 to 21 percent, garnet 1 to 5 percent, and others 2 to 9 percent.

In sample 13 the quartz breakdown was I-41 percent, II-7 percent, III-4 percent, IV-5 percent, V-7 percent, VI-2 percent, VII-0 percent, VIII-1 percent, giving a total of 67 percent. Chalcedony had 20 percent, orthoclase 4 percent, microcline 1 percent, plagaclase 7 percent, and ash 0 percent. The heavies had opaques 15 percent, amphiboles and pyroxenes 46 percent, zircon 7 percent, epidote 6 percent, monazite 4 percent, micas 11 percent, garnet 3 percent, and others 8 percent.

In sample 14 the material was very fine and silty with a light color. The quartz had I-35 percent, II-4 percent, III-1 percent, IV-11 percent, V-11 percent, VI-1 percent, VII-2 percent, VIII-1 percent, giving a total of 66 percent. Chalcedony had 16 percent, orthoclase 4 percent, microcline 2 percent, plagaclase 9 percent, and ash had 3 percent. The heavy fraction had opaques 6 percent, emphiboles and pyroxenes 41 percent, zircon 4 percent, micas 41 percent, epidote 2 percent, monazite 1 percent, garnet 2 percent, and others 2 percent.

In sample 15 the texture was the average fine sand and the average fine sand and the color was light due to so much quartz. The quartz had I-31 percent, II-8 percent, III-6 percent, IV-6 percent, V-6 percent, VI-1 percent, VII-1 percent, and VIII-3 percent, giving a total of 62 percent quartz. Chalcedony had 16 percent, orthoclase 7 percent, microcline 4 percent, plagaclase 9 percent, and ash 2 percent. The heavies had opaques 11 percent, zircon 16 percent, amphiboles and pyroxenes 48 percent, epidote 5 percent, monazite 2 percent, micas 6 percent, garnet 2 percent, and others 10 percent.

Sample 16 had normal texture and color. The quartz had I-36 percent, II-9 percent, III-9 percent, IV-15 percent, V-3 percent, VI-2 percent, VII-1 percent, and VIII-0 percent, giving a total of 75 percent. Chalcedony had 11 percent, orthoclase 4 percent, microcline 1 percent, plagaclase 6 percent, and ash 1 percent. The heavy fraction had opaques 10 percent, micas 4 percent, amphiboles and pyroxenes 47 percent, zircon 19 percent, epidote 11 percent, monazite 6 percent, garnet 1 percent, and others 2 percent.

In sample 19 the color and texture were average. The quartz had I-37 percent, II-9 percent, III-3 percent, IV-4 percent, V-5 percent, VI-3 percent, VII-1 percent, and VIII-1 percent, giving a total of 63 percent. Chalcedony had 25 percent, orthoclase 3 percent, microcline 2 percent, plagaclase 6 percent, and ash 0 percent. The heavies had opaques 17 percent, micas 3 percent, amphiboles and pyroxenes 44 percent, zircon 21 percent, epidote 7 percent, monazite 3 percent, garnet 3 percent, and 2 percent others.

In sample 29 the texture was more coarse than average, and the color was about as dark as any used in this study due to the amount of opaques. The quartz had I-35 percent, II-9 percent, III-8 percent, IV-13 percent, V-1 percent, VI-4 percent, VII-0 percent, and VIII-0 percent, giving a total of 70 percent.

Chalcedony had 16 percent, orthoclase 7 percent, microcline 1 percent, plagaclase 5 percent, and ash 0 percent. The heavy fraction had opaques 58 percent, amphiboles and pyroxenes 20 percent, zircon 7 percent, micas 2 percent, epidote 4 percent, monazite 2 percent, garnet 5 percent, and others 2 percent.

An average of the samples in Table 2 showed the light mineral fraction to have I-36 percent, II-7 percent, III-5 percent, IV-8 percent, V-6 percent, VI-2 percent, VII-1 percent, and VIII-1 percent for a total of 67 percent quartz. Chalcedony had 18 percent, orthoclase 4 percent, plagaclase 7 percent, and ash 1 percent. The average for the heavy fraction had 12 percent opaques, amphiboles and pyroxenes 47 percent, zircon 13 percent, epidote 6 percent, monazite 3 percent, garnet 3 percent, micas 6 percent, and 3 percent others. The two samples (14 and 29) were left out of this table when the average was taken. The reason for this was that the placer and anti-placer results found in the two samples caused them to be out of proportion to the other samples.

The Wildcat Creek Area

The samples of the Wildcat Creek area were located in an area one mile long and a half-mile wide. Samples were taken from both sides of the creek north of U. S. Highway 40. The samples were taken in September of 1951, and the depth of the new deposits was more evident than those taken at later dates. The depth of these samples was limited to six inches to one foot, because of the shallowness of the deposits in the area. Color and texture ran about the same with the exception of a little more organic matter

Table 2. Hunter's Island: Quantitative mineral analysis.

Minerals	Sample numbers 13	14*	15	16	19	29*	Average
				Heavy fraction			
Magnetite	6	2	5	1	9	53	4.6
Ilmenite	9	4	6	9	8	5	7.2
Zircon	7	4	16	19	21	7	13.4
Topaz	0	0	2	0	0	1	0.4
Hornblende	46	41	48	47	44	20	45.2
Epidote	6	2	5	11	7	4	5.8
Muscovite	10	41	6	2	3	2	5.0
Biotite	1	0	0	2	0	0	0.6
Garnet	3	2	2	1	3	5	3.2
Monazite	4	2	2	6	3	2	3.1
Tourmaline	4	0	3	0	1	0	1.6
Rutile	1	1	2	0	0	0	0.8
Tremolite-Actinline	3	1	3	2	1	1	2.0
				Light fraction			
Quartz	67	66	62	75	63	70	66.6
Chalcedony	20	16	16	11	25	16	17.6
Orthoclase	4	4	7	4	3	7	4.4
Microcline	1	2	4	1	2	1	1.0
Plagaclase	7	9	9	6	6	5	7.4
Ash	0	3	2	1	0	0	1.0

Table 2 (concl.).

Minerals	Sample numbers 13	14*	15	16	19	29*	Average
			Classification of quartz				
I	41	35	31	36	37	35	36.0
II	7	4	8	9	9	9	7.4
III	4	1	6	9	3	8	4.6
IV	5	11	6	15	4	13	8.2
V	7	11	6	3	5	1	6.4
VI	2	1	1	2	3	4	1.8
VII	0	2	1	1	1	0	1.0
VIII	1	1	3	0	1	0	1.2
Total quartz	67	66	62	75	63	70	66.6

* Samples number 14 and 29 were not included in the average, as explained on page 61.

present.

The quartz percentage was 52 to 69, chalcedony was 18 to 38 percent, feldspars 10 to 12 percent, volcanic ash 0 to 1 percent. The heavy fraction had opaques 10 to 38 percent, amphiboles and pyroxenes 26 to 51 percent, muscovite and biotite 1 to 16 percent, epidote 1 to 8 percent, monazite 1 to 8 percent, zircon 1 to 34 percent, garnet 2 to 11 percent, and others 1 to 6 percent.

In sample 20, texture and color were average, and the quartz had I-30 percent, II-7 percent, III-8 percent, IV-12 percent, V-2 percent, VI-6 percent, VII-1 percent, and VIII-0 percent, giving a total of 66 percent. Chalcedony had 23 percent, orthoclase 6 percent, microcline 1 percent, plagaclase 4 percent, and ash 0 percent. The heavy fraction had opaques 34 percent, amphiboles and pyroxenes 29 percent, zircon 13 percent, micas 1 percent, epidote 8 percent, monazite 6 percent, garnet 6 percent, and others 3 percent.

In sample 21 the texture and color of the sample were about average, and the quartz had I-33 percent, II-3 percent, III-5 percent, IV-6 percent, V-0 percent, VI-4 percent, VII-0 percent, and VIII-0 percent, giving a total of 52 percent. Chalcedony had 38 percent, orthoclase 5 percent, microcline 2 percent, plagaclase 3 percent, and ash 0 percent. The heavy fraction had opaques 30 percent, amphiboles and pyroxenes 26 percent, zircon 13 percent, micas 16 percent, epidote 4 percent, monazite 4 percent, garnet 5 percent, and others 2 percent.

In sample 22 the texture and color were about average. Quartz had I-32 percent, II-5 percent, III-6 percent, IV-7 percent, V-1 percent, VI-2 percent, VII-1 percent, and VIII-0 percent, giving a total of 54 percent. Chalcedony had 36 percent, orthoclase 5 percent, microcline 1 percent, plagaclase 3 percent, and ash 1 percent. The heavy fraction had opaques 22 percent, amphiboles and pyroxenes 31 percent, zircon 31 percent, micas 1 percent, monazite 4 percent, epidote 4 percent, garnet 5 percent, and other minerals 3 percent.

In sample 23 the texture and color was fine and light. Quartz had I-40 percent, II-7 percent, III-7 percent, IV-4 percent, V-2 percent, VI-4 percent, VII-1 percent, and VIII-0 percent, giving a total of 65 percent. Chalcedony had 2 percent, orthoclase 6 percent, microcline 1 percent, plagaclase 6 percent, and ash 0 percent. The heavy fraction had opaques 11 percent, amphiboles and pyroxenes 39 percent, zircon 19 percent, epidote 7 percent, monazite 6 percent, garnet 5 percent, micas 10 percent, and, others 3 percent.

In sample 24 the same light color and fine texture were found. The quartz had I-31 percent, II-6 percent, III-7 percent, IV-12 percent, V-2 percent, VI-5 percent, VII-1 percent, and VIII-1 percent, giving a total of 65 percent. Chalcedony had 23 percent, orthoclase 5 percent, microcline 2 percent, plagaclase 4 percent, and ash had 0 percent. The heavy fraction had opaques 17 percent, amphiboles and pyroxenes 51 percent, zircon 10 percent, epidote 4 percent, monazite 4 percent, garnet 6 percent, micas 6 percent, and other minerals 2 percent.

In sample 25 the texture was fine and the color the same light appearance. Quartz had I-39 percent, II-6 percent, III-2 percent, IV-10 percent, VI-1 percent, VI-3 percent, VII-1 percent, and VIII-0 percent, giving a total of 62 percent. Chalcedony had 24 percent, orthoclase 8 percent, microcline 2 percent, plagaclase 3 percent, and ash had 0 percent. The heavy fraction had opaques 11 percent, amphiboles and pyroxenes 43 percent, zircon 10 percent, micas 14 percent, epidote 3 percent, monazite 5 percent, garnet 11 percent, and others 3 percent.

In sample 26 the texture was medium coarse, and the color was darker than average. Quartz had I-37 percent, II-9 percent, III-5 percent, IV-14 percent, V-1 percent, VI-3 percent, VII-0 percent, and VIII-0 percent, giving a total of 69 percent. Chalcedony had 18 percent, orthoclase 5 percent, microcline 2 percent, plagaclase 4 percent, and ash 0 percent. The heavy fraction had opaques 38 percent, amphiboles and pyroxenes 35 percent, zircon 1 percent, epidote 0 percent, monazite 1 percent, garnet 2 percent, micas 16 percent, and others 7 percent.

An average of the samples in Table 3 showed the light mineral fraction to have I-35 percent, II-6 percent, III-6 percent, IV-9 percent, V-1 percent, VI-4 percent, and VII and VIII had 1 percent, giving a total of 62 percent quartz. Chalcedony had 26 percent, orthoclase 6 percent, plagaclase 4 percent, microcline 2 percent, and ash 0.1 percent. The average for the heavy fraction showed opaques 24 percent, amphiboles and pyroxenes 36 percent, zircon 14 percent, garnet 6 percent, micas 9 percent, monazite 4 percent, epidote 4 percent, and 2 percent others.

Table 3. Wildcat Creek: Quantitative mineral analysis.

Minerals	20	21	22	23	24	25	26	Average
	Sample numbers							
Heavy fraction								
Magnetite	19	19	11	3	5	5	3	9.1
Ilmenite	15	11	11	8	12	6	35	14.0
Zircon	13	13	31	19	10	10	1	13.9
Topaz	0	0	0	0	0	0	1	0.1
Hornblende	29	26	31	39	51	43	35	36.3
Epidote	8	4	4	7	4	3	0	4.3
Monazite	6	4	4	6	4	5	1	4.3
Muscovite	1	16	1	10	6	14	16	9.0
Garnet	6	5	5	5	6	11	2	5.7
Tourmaline	1	1	1	2	1	0	1	1.0
Tremolite-Actinlite	2	1	1	1	1	3	5	2.0
Light fraction								
Quartz	66	52	54	65	65	62	69	62.0
Chalcedony	23	38	36	22	23	24	18	26.5
Orthoclase	6	5	5	6	5	8	5	5.7
Microcline	1	2	1	1	2	2	2	1.6
Plagaclase	4	3	3	6	4	3	4	4.0
Ash	0	0	1	0	0	0	0	0.1

Table 3 (concl.).

Minerals	Sample numbers 20	21	22	23	24	25	26	Average
				Classification of quartz				
I	30	33	32	40	31	39	37	34.6
II	7	3	5	7	6	6	9	6.1
III	8	5	6	7	7	2	5	5.7
IV	12	6	7	4	12	10	14	9.3
V	2	0	1	2	2	1	1	1.3
VI	6	4	2	4	5	3	3	4.0
VII	1	0	1	1	1	1	0	0.7
VIII	0	0	0	0	1	0	0	0.1
Total quartz	66	52	54	65	65	62	69	62.0

The Manhattan Area

The samples of the Manhattan area were located over an area of one square mile from the base of "K" hill to a sample spot north of U. S. Highway 40 near the Pottawatomie Airport. These samples were taken in September of 1951, and the depths of the new deposits were more evident than those taken at a later date. The depths of these samples varied from six inches to three feet, and in some spots more than one sample was taken. Color and texture were about the same except for some very coarse material in a few of the more eastern samples. The quartz made up the largest percentage of the light fraction, 61 to 73 percent. The chalcedony was 13 to 23 percent, feldspars 7 to 15 percent, volcanic ash 1 to 7 percent. The heavy fraction had opaques 4 to 18 percent, amphiboles and pyroxenes 36 to 53 percent, muscovite and biotite 3 to 43 percent, epidote 1 to 7 percent, monazite 1 to 3 percent, zircon 8 to 25 percent, garnet 1 to 6 percent, and others 1 to 7 percent.

In sample 36 the color was quite light and the texture was very fine and silty. The quartz showed the following varieties: I-31 percent, II-6 percent, III-7 percent, IV-10 percent, V-2 percent, VI-4 percent, VII-0 percent, and VIII-1 percent, giving a total of 61 percent. Chalcedony had 23 percent, orthoclase 3 percent, microcline 1 percent, plagaclase 3 percent, and ash 7 percent. The heavy fraction had opaques 6 percent, amphiboles and pyroxenes 36 percent, zircon 8 percent, epidote 1 percent, monazite 2 percent, micas 43 percent, garnet 1 percent, and others 5 percent.

In sample 27_a the color was lighter than usual and quite fine. The quartz had I-31 percent, II-10 percent, III-11 percent, IV-12 percent, V-3 percent, VI-5 percent, VII-1 percent, and VIII-0 percent, giving a total of 73 percent. Chalcedony had 13 percent, orthoclase 5 percent, microcline 2 percent, plagaclase 5 percent, and ash 1 percent. The heavy fraction had opaques 4 percent, amphiboles and pyroxenes 44 percent, zircon 14 percent, epidote 7 percent, monazite 1 percent, micas 21 percent, garnet 1 percent, and others 7 percent.

In sample 27_b which was taken six inches below sample 27_a, the quartz had I-44 percent, II-6 percent, III-8 percent, IV-6 percent, V-3 percent, VI-2 percent, VII-1 percent, VIII-1 percent, giving a total of 71 percent. Chalcedony had 14 percent, orthoclase 6 percent, microcline 1 percent, plagaclase 5 percent, and ash 1 percent. The heavy fraction had opaques 7 percent, amphiboles and pyroxenes 57 percent, zircon 20 percent, micas 9 percent, epidote 3 percent, monazite 1 percent, garnet 1 percent, and others 2 percent.

In sample 17 the texture and color were about average. The quartz had I-39 percent, II-8 percent, III-4 percent, IV-6 percent, V-6 percent, VI-2 percent, VII-0 percent, and VIII-1 percent, giving a total of 67 percent. Chalcedony had 19 percent, orthoclase 4 percent, microcline 3 percent, plagaclase 6 percent, and ash had 1 percent. The heavy fraction had opaques 9 percent, amphiboles and pyroxenes 53 percent, micas 4 percent, zircon 18 percent, epidote 5 percent, monazite 2 percent, garnet 4 percent, and others 5 percent.

In sample 18 the color and texture were average. The quartz had I-41 percent, II-11 percent, III-4 percent, IV-5 percent, V-8 percent, VI-1 percent, VII-2 percent, and VIII-0 percent, giving a total of 72 percent. Chalcedony had 17 percent, orthoclase 2 percent, microcline 2 percent, plagaclase 5 percent, and ash had 1 percent. The heavy fraction had opaques 11 percent, micas 3 percent, amphiboles and pyroxenes 46 percent, epidote 5 percent, zircon 26 percent, monazite 2 percent, garnet 2 percent, and others 5 percent.

In sample 28_a the texture and color were about normal. The quartz had I-46 percent, II-6 percent, III-5 percent, IV-8 percent, V-3 percent, VI-4 percent, VII-0 percent, and VIII-1 percent, giving a total of 72 percent. Chalcedony had 15 percent, orthoclase 6 percent, microcline 2 percent, plagaclase 4 percent, and ash had 1 percent. The heavy fraction had opaques 12 percent, micas 4 percent, zircon 16 percent, amphiboles and pyroxenes 43 percent, epidote 18 percent, monazite 3 percent, garnet 3 percent, and others 1 percent.

In sample 28_b the texture and color were about normal. It was collected from below sample 28_a at a depth of 30 inches. The quartz had I-40 percent, II-5 percent, III-6 percent, IV-9 percent, V-1 percent, VI-3 percent, VII-0 percent, and VIII-1 percent, giving a total of 65 percent. Chalcedony had 19 percent, orthoclase 9 percent, microcline 2 percent, plagaclase 3 percent, and ash had 2 percent. The heavy fraction had opaques 18 percent, zircon 22 percent, amphiboles and pyroxenes 42 percent, micas 5 percent, epidote 3 percent, monazite 3 percent, garnet 6 percent, and others 1 percent.

In sample 30_a the texture and color were about normal. The sample was taken at 24 inches. The quartz had I-35 percent, II-10 percent, III-8 percent, IV-9 percent, V-2 percent, VI-4 percent, VII and VIII-0 percent, giving a total of 68 percent. Chalcedony had 15 percent, orthoclase 9 percent, microcline 2 percent, plagaclase 4 percent, and ash had 2 percent. The heavy fraction had opaques 8 percent, amphiboles and pyroxenes 48 percent, zircon 17 percent, micas 17 percent, epidote 3 percent, monazite 2 percent, garnet 3 percent, and others 2 percent.

In sample 30_b the texture and color were about the same as 30_a, but there was not as much fine silt. The quartz had I-30 percent, II-8 percent, III-11 percent, IV-12 percent, V-2 percent, VI-4 percent, VII-1 percent, VIII-1 percent, giving a total of 69 percent. Chalcedony had 14 percent, orthoclase 8 percent, microcline 2 percent, plagaclase 2 percent, and ash 1 percent. The heavy fraction had opaques 12 percent, amphiboles and pyroxenes 47 percent, zircon 16 percent, micas 11 percent, epidote 3 percent, monazite 2 percent, garnet 5 percent, and others 4 percent.

An average of Table 4 showed the light fraction to have I-38 percent, II-8 percent, III-7 percent, IV-8 percent, V-4 percent, VI-3 percent, VII and VIII-1 percent, giving a total of 70 percent quartz. Chalcedony had 16 percent, orthoclase 6 percent, microcline 2 percent, plagaclase 4 percent, and ash 1 percent. The heavy fraction showed opaques 9 percent, zircon 18 percent, amphiboles and pyroxenes 48 percent, monazite 2 percent, epidote 6 percent, garnet 3 percent, micas 9 percent, and 2 percent others.

Table 4. The Manhattan area: Quantitative mineral analysis.

Minerals	Sample numbers									Average
	17	18	36*	27_a	27_b	28_a	28_b	30_a	30_b	
					Heavy fraction					
Hematite	0	0	0	0	1	1	0	0	0	0.2
Magnetite	1	2	0	0	1	5	11	3	7	3.3
Ilmenite	8	9	6	4	5	6	7	5	5	6.0
Zircon	18	26	8	14	20	16	22	17	16	18.6
Topaz	1	1	1	0	1	0	0	0	1	0.5
Hornblende	53	46	36	44	57	43	42	48	47	47.5
Epidote	5	5	1	7	3	18	3	3	3	6.0
Muscovite	4	3	43	21	9	4	5	17	11	9.1
Biotite	1	0	0	1	0	0	0	0	0	0.2
Garnet	3	2	1	1	2	3	6	3	5	3.1
Augite	0	1	0	0	0	0	0	1	1	0.4
Kyanite	0	0	0	1	0	0	0	0	1	0.2
Tourmaline	2	0	1	1	0	1	0	0	0	0.5
Rutile	0	0	0	1	0	0	1	1	0	0.5
Lamproblite	1	0	0	0	0	0	0	1	1	0.5
Tremolite-Actinlite	1	2	1	4	0	0	0	0	0	0.9
Monazite	2	2	2	1	1	3	3	2	2	2.0
					Light fraction					
Quartz	67	72	61	73	71	72	65	68	69	69.6
Chalcedony	19	17	23	13	14	15	19	15	14	15.8
Orthoclase	4	2	3	5	6	6	9	9	8	6.1
Microcline	3	2	1	2	1	2	2	2	2	2.0
Plagaclase	6	5	3	4	5	4	3	4	2	4.1
Ash	1	1	7	1	1	1	2	2	1	1.2

Table 4 (concl.).

Minerals	Sample numbers									Average
	17	18	36*	27_a	27_b	28_a	28_b	30_a	30_b	
					Classification of Quartz					
I	39	41	31	31	44	46	40	35	30	38.3
II	8	11	6	10	6	6	5	10	8	8.0
III	4	4	7	11	8	5	6	8	11	7.1
IV	6	5	10	12	6	8	9	9	12	8.3
V	6	8	2	3	3	3	1	2	2	3.5
VI	2	1	4	5	2	4	3	4	4	3.1
VII	0	2	0	1	1	0	0	0	1	0.6
VIII	1	0	1	0	1	1	1	0	1	0.6
Total quartz	67	72	61	73	71	72	65	68	69	69.6

* Sample 36 was not included in the average, as explained on page 61.

Sample 36 was not included in the average, because of its excessive mica flood content.

The Blue River Area

The samples of the Blue River area were gathered from an area of about one square mile, from the junction of the Blue and the Kaw to a spot one mile north of U. S. Highway 40. These samples were taken in 1951 at about the same time as the samples from the Manhattan area were taken. The samples varied in depth from a foot to three feet, and at one spot two samples were taken.

Quartz made up the largest percentage of the light fraction, 70 to 77 percent. Chalcedony was 12 to 19 percent, feldspars 10 to 12 percent, and ash 0 to 1 percent. The heavy fraction had opaques 12 to 24 percent, amphiboles and pyroxenes 32 to 52 percent, epidote 2 to 4 percent, muscovite and biotite 2 to 10 percent, monazite 3 to 5 percent, garnet 2 to 8 percent, zircon 16 to 24 percent, and others 2 to 5 percent.

In sample 31 the normal texture and light color were present. The quartz had I-35 percent, II-9 percent, III-11 percent, IV-12 percent, V-2 percent, VI-5 percent, VII-0 percent, and VIII-1 percent, giving a total of 74 percent. Chalcedony had 14 percent, orthoclase 6 percent, microcline 1 percent, plagaclase 4 percent, and ash 0 percent. The heavy fraction had opaques 12 percent, amphiboles and pyroxenes 52 percent, micas 9 percent, zircon 16 percent, epidote 2 percent, monazite 3 percent, garnet 4 percent, and others 2 percent.

In sample 32 the texture and color were normal. The quartz had I-33 percent, II-10 percent, III-10 percent, IV-11 percent, V-1 percent, VI-4 percent, VII-0 percent, and VIII-1 percent, giving a total of 70 percent. Chalcedony had 16 percent, orthoclase 6 percent, microcline 0 percent, plagaclase 4 percent, and ash 0 percent. The heavy fraction had opaques 21 percent, biotite 10 percent, emphiboles and pyroxenes 32 percent, zircon 24 percent, epidote 2 percent, monazite 3 percent, garnet 4 percent and others 5 percent.

In sample 33 the texture and color were about normal. The quartz had I-28 percent, II-13 percent, III-10 percent, IV-12 percent, V-3 percent, VI-6 percent, VII-2 percent, and VIII-0 percent, giving a total of 74 percent. Chalcedony had 13 percent, orthoclase 6 percent, microcline 1 percent, plagaclase 5 percent, and ash 0 percent. The heavy mineral fraction had opaques 20 percent, amphiboles and pyroxenes 42 percent, micas 5 percent, zircon 20 percent, epidote 4 percent, monazite 4 percent, garnet 2 percent, and others 3 percent.

In sample 34 the texture was about normal and the color was a little darker. The quartz had I-29 percent, II-15 percent, III-12 percent, IV-12 percent, V-1 percent, VI-6 percent, VII-1 percent, and VIII-1 percent, giving a total of 77 percent. Chalcedony had 12 percent, orthoclase 5 percent, microcline 1 percent, plagaclase 3 percent, and ash had 1 percent. The heavy fraction had opaques 24 percent, amphiboles and pyroxenes 40 percent, zircon 16 percent, micas 8 percent, epidote 2 percent, monazite 3 percent, garnet 3 percent, and others 4 percent.

In sample 35_a the texture was about normal and the color was average. The quartz had I-31 percent, II-14 percent, III-10 percent, IV-11 percent, V-1 percent, VI-2 percent, VII-1 percent, and VIII-0 percent, giving a total of 70 percent. Chalcedony had 19 percent, orthoclase 4 percent, microcline 3 percent, plagaclase 3 percent, and ash 0 percent. The heavy fraction had opaques 23 percent, micas 6 percent, amphiboles and pyroxenes 43 percent, zircon 16 percent, epidote 2 percent, monazite 3 percent, garnet 2 percent, and others 5 percent.

In sample 35_b, found 8 to 14 inches below sample 35_a, the color and texture were about normal. The quartz had I-30 percent, II-14 percent, III-9 percent, IV-12 percent, V-2 percent, VI-3 percent, VII-1 percent, and VIII-0 percent, giving a total of 71 percent. Chalcedony had 19 percent, orthoclase 7 percent, microcline 1 percent, plagaclase 2 percent, and ash 0 percent. The heavy fraction had opaques 22 percent, amphiboles and pyroxenes 36 percent, zircon 18 percent, micas 2 percent, epidote 4 percent, monazite 5 percent, garnet 8 percent, and other minerals 5 percent.

An average for Table 5 showed the light fraction to have I-31 percent, II-13 percent, III-10 percent, IV-12 percent, V-2 percent, VI-4 percent, VII and VIII-1 percent, giving a total of 73 percent quartz. Chalcedony had 16 percent, orthoclase 6 percent, microcline 1 percent, plagaclase 4 percent, and ash 0.1 percent. The heavy fraction had opaques 20 percent, zircon 18 percent, amphiboles and pyroxenes 42 percent, epidote 3 percent, muscovite and biotite 7 percent, garnet 4 percent, monazite 4 percent, and 3 percent others.

Table 5. The Blue River area: Quantitative mineral analysis.

Minerals	Sample numbers						Average
	31	32	33	34	35_a	35_b	
			Heavy fraction				
Hematite	0	0	0	0	0	0	0.0
Magnetite	6	13	3	14	16	12	10.7
Ilmenite	6	8	17	10	7	10	9.7
Zircon	16	24	20	16	16	18	18.3
Topaz	0	1	0	0	1	0	0.3
Hornblende	52	32	42	40	43	36	41.0
Epidote	2	2	4	2	2	4	2.7
Muscovite	9	0	5	6	5	2	4.5
Biotite	0	10	0	2	1	0	2.1
Garnet	4	4	2	3	2	8	4.0
Augite	1	1	1	1	1	1	1.0
Kyanite	0	0	0	0	0	0	0.0
Tourmaline	0	0	0	1	0	1	0.3
Rutile	0	0	1	0	0	1	0.3
Lamproblite	1	1	0	2	1	2	1.1
Actinlite	0	2	1	0	2	0	0.9
Monazite	3	3	4	3	3	5	3.5
			Light fraction				
Quartz	74	70	74	77	70	71	72.7
Chalcedony	14	16	13	12	19	19	15.5
Orthoclase	6	6	6	5	4	7	5.7
Microcline	1	0	1	2	3	1	1.3
Plagaclase	4	4	5	3	3	2	3.5
Ash	0	0	0	1	0	0	0.1

Table 5 (concl.).

Minerals	Sample numbers 31	32	33	34	35_a	35_b	Average
	Classification of quartz						
I	35	33	28	29	31	30	31.0
II	9	10	13	15	14	14	12.5
III	11	10	10	12	10	9	10.3
IV	12	11	12	12	11	12	11.7
V	2	1	3	1	1	2	1.7
VI	5	4	6	6	2	3	4.3
VII	0	0	2	1	1	1	0.8
VIII	1	1	0	1	0	0	0.5
Total quartz	74	70	74	77	70	71	72.7

The grand average for this work (1951 flood) showed the light fraction to have 67 percent quartz, 18 percent chalcedony, 14 percent feldspars, and less than 1 percent glass. The heavy fraction showed 19 percent opaques, 43 percent amphiboles and pyroxenes, 7 percent muscovite and biotite, 5 percent epidote, 4 percent garnet, and 21 percent others.

Types of quartz in the light fraction were: I-35 percent, II-8 percent,III-7 percent, IV-8 percent, V-3 percent, VI-3 percent, and VII and VIII-1 percent.

Material for Study

In an attempt to find the origin of the 1951 flood deposits, data dealing with the Kaw River, its possible source materials, and its tributaries were collected for study. Material found in Seiler's thesis was on transported dust, samples from the 1935 flood, samples from the 1950 flood, samples from the cut banks of the Solomon River, Saline River, and Salt Creek, and the glacial terraces along the Kansas River.

The 1950 flood showed the light fraction to have 64 percent quartz, chalcedony 15 percent, feldspars 21 percent, and no ash. The heavy fraction showed opaques 13 percent, amphiboles and pyroxenes 35 percent, micas 9 percent, epidote 12 percent, garnet 4 percent, and 27 percent others.

The 1935 flood showed a somewhat different analysis. Quartz showed 23 percent, chalcedony 67 percent, feldspars 8 percent, and ash 2 percent. The heavy mineral fraction showed opaques 9 percent, amphiboles and pyroxenes 31 percent, muscovite and biotite

Table 6. Averages for areas studied and grand total.

Minerals	Ogden	Hunter's Island	Wildcat Creek	Manhattan	Blue River	Grand total
	Area names					
			Heavy fraction			
Hematite	0.2	0.0	0.0	0.2	0.0	0.1
Magnetite	17.0	4.6	9.1	3.3	10.7	8.9
Ilmenite	10.3	7.2	14.0	6.0	9.7	9.4
Zircon	13.0	13.4	13.9	18.6	18.3	15.4
Topaz	0.5	0.4	0.1	0.5	0.5	0.3
Hornblende	38.1	45.2	36.3	47.5	41.0	41.6
Epidote	5.0	5.8	4.3	6.0	2.7	4.6
Muscovite	5.3	5.0	9.0	9.1	4.5	6.6
Biotite	0.8	0.6	0.0	0.2	2.0	0.7
Garnet	5.3	3.0	5.7	3.1	4.0	4.2
Augite	0.0	0.0	0.0	0.4	1.0	0.3
Kyanite	0.0	0.0	0.0	0.2	0.0	0.1
Tourmaline	0.6	1.6	1.0	0.5	0.3	0.8
Rutile	0.2	0.8	0.0	0.4	0.3	0.3
Lamproblite	0.0	0.0	0.0	0.5	1.0	0.3
Actinlite	1.3	2.0	2.0	0.9	0.0	1.2
Monazite	2.8	3.1	4.3	2.0	3.5	3.1
			Light fraction			
Quartz	66.5	66.6	62.0	69.6	72.7	67.5
Chalcedony	15.8	17.6	26.5	15.8	15.5	18.0
Orthoclase	6.0	4.4	5.7	6.1	5.7	5.5
Plagaclase	6.3	7.4	4.0	4.1	3.5	5.1
Microcline	2.0	1.0	1.6	2.0	1.3	1.6
Ash	0.5	1.2	0.1	1.2	0.1	0.6

Table 6 (concl.).

Minerals	Ogden	Hunter's Island	Wildcat Creek	Manhattan	Blue River	Grand total
	Area names					
	Classification of quartz					
I	33.3	36.0	34.6	38.3	31.0	34.6
II	7.2	7.4	6.1	8.0	12.5	8.2
III	8.0	4.6	5.7	7.1	10.3	7.1
IV	13.2	8.2	9.3	8.3	11.7	8.3
V	0.6	6.4	1.3	3.5	1.7	2.7
VI	3.0	1.8	4.0	3.1	4.3	3.2
VII	0.2	1.0	0.7	0.6	0.8	0.6
VIII	0.3	1.2	0.1	0.6	0.5	0.5
Total quartz	66.5	66.6	62.0	69.6	72.7	67.5

39 percent, epidote 5 percent, garnet 1 percent, and others 15 percent.

Dust from a porch (air transported) showed quartz 47 percent, chalcedony 28 percent, feldspars 20 percent, and ash 5 percent. The heavy fraction showed opaques 6 percent, emphiboles and pyroxenes 25 percent, muscovite and biotite 38 percent, epidote 5 percent, garnet 1 percent, and others 23 percent.

The terrace at Zeandale showed the light fraction to have quartz 65 percent, chalcedony 25 percent, feldspars 10 percent, and ash 1 percent. The heavy fraction showed opaques 50 percent, amphiboles and pyroxenes 3 percent, micas 21 percent, epidote 5 percent, garnet 4 percent, and others 17 percent.

The Wamego terraces showed the light fraction to have 50 percent quartz, 35 percent chalcedony, 15 percent feldspars, and no ash. The heavy fraction showed opaques 26 percent, amphiboles and pyroxenes 11 percent, micas 32 percent, epidote 13 percent, garnet 3 percent, and others 12 percent.

The Saline and Solomon Rivers and Salt Creek showed the light fraction to have quartz 57 percent, chalcedony 27 percent, feldspars 14 percent, and 2 percent ash. The heavy fraction showed opaques 32 percent, emphiboles and pyroxenes 26 percent, micas 18 percent, epidote 7 percent, garnet 2 percent, and others 15 percent.

Seiler's work gave a good coverage of the type of material found in the bed of the Kansas River flood plain from the surface to about 25 feet in depth. The upper limits of the flood plain material, or post-volcanic ash (age period), showed the light fraction to have quartz 55 percent, chalcedony 22 percent, feldspars 20 percent, and 3 percent ash. The heavy fraction had opaques 17 percent, amphiboles and pyroxenes 36 percent, micas 23 percent, epidote 11 percent, garnet 4 percent, and 9 percent others.

The volcanic ash (age period) showed the light fraction to have quartz 25 percent, chalcedony 32 percent, 7 percent feldspars, ash 36 percent. The heavy fraction had opaques 6 percent, amphiboles and pyroxenes 12 percent, micas 75 percent, epidote 3 percent, garnet 1 percent, and others 3 percent.

The volcanic ash (age period) contained such an excess of mica, that to obtain a true mineral percentage for comparison with the sediments above and below it in the flood plain, a recalculation of the percentages had to be made. This was done by taking an approximate normal average of ash and mica which in this case was 1 percent and 25 percent, respectively. Then the other mineral percentages were raised in proportion to their original percentages to total 100 percent. Thus, according to recalculation, the light fraction showed quartz to have 38 percent, chalcedony 49 percent, feldspars 10 percent, and ash 1 percent. The heavy fraction showed opaques to have 10 percent, amphiboles and pyroxenes 36 percent, micas 25 percent, epidote 9 percent, garnet 3 percent, and others 9 percent.

The pre-volcanic ash (age period) showed the light fraction to have quartz 44 percent, chalcedony 38 percent, feldspars 12 percent, and ash 6 percent. The heavy fraction showed opaques 15 percent, amphiboles and pyroxenes 32 percent, micas 34 percent, epidote 9 percent, garnet 2 percent, and others 8 percent.

Work by Harned showed samples taken from the following materials: upland non-residual, Kaw Valley terrace mantle, Kaw River alluvium, Permian shale mantle, Smokey Hill River alluvium, Republican River alluvium, and glacial drift.

The upland (non-residual) showed a light fraction of quartz 70 percent, chalcedony 22 percent, feldspars 8 percent, and 0 percent ash. The heavy fraction showed opaques 26 percent, amphiboles and pyroxenes 31 percent, micas 10 percent, epidote 14 percent, garnet 3 percent, and others 16 percent.

The Kaw Valley terrace mantle showed the light fraction to have quartz 53 percent, chalcedony 38 percent, feldspars 9 percent, and ash 0 percent. The heavy fraction showed opaques 22 percent, amphiboles and pyroxenes 26 percent, micas 11 percent, epidote 13 percent, garnet 4 percent, and others 19 percent.

The Kaw River alluvium showed the light fraction to have quartz 69 percent, chalcedony 19 percent, feldspars 11 percent, and ash 0 percent. The heavy fraction showed opaques 30 percent, amphiboles and pyroxenes 34 percent, micas 6 percent, epidote 15 percent, garnet 5 percent, and others 10 percent.

The Permian shale mantle showed the light fraction to have quartz 16 percent, chalcedony 75 percent, feldspars 9 percent, and ash 0 percent. The heavy fraction showed opaques 27 percent, amphiboles and pyroxenes 10 percent, micas 24 percent, epidote 5 percent, garnet 3 percent, and others 27 percent.

The Smokey Hill River alluvium showed the light fraction to have quartz 45 percent, chalcedony 46 percent, feldspars 9 percent, and ash 0 percent. The heavy fraction showed opaques 26 percent, amphiboles and pyroxenes 36 percent, micas 14 percent, epidote 8 percent, garnet 2 percent, and others 9 percent.

The Republican River showed the light fraction to have quartz 43 percent, chalcedony 32 percent, feldspars 11 percent, and ash 9 percent. The heavy fraction showed opaques 8 percent, amphiboles and pyroxenes 32 percent, micas 39 percent, epidote 8 percent, garnet 3 percent, and others 8 percent.

Glacial drift showed the light fraction to have quartz 59 percent, chalcedony 22 percent, feldspars 19 percent, and ash 0 percent. The heavy fraction showed opaques 39 percent, amphiboles and pyroxenes 21 percent, micas 4 percent, epidote 10 percent, garnet 5 percent, and others 20 percent.

Glacial Till showed a light fraction of 71 percent quartz, 18 percent chalcedony, 9 percent feldspars, and no ash. The heavy fraction showed 32 percent opaques, 16 percent amphiboles and pyroxenes, 10 percent micas, 17 percent epidote, 7 percent garnet, and 13 percent others.

ORIGIN OF THE 1951 FLOOD DEPOSITS

A Study of the 1951 Flood Deposits

A study of the material present in the Kaw River, its tributaries and basin leave little doubt as to the origin of the 1951 flood sediments. The 1951 flood deposits were for the greater part due to material eroded locally from the channel and flood plain of the Kaw River. This is shown by the relationship of the

Table 7. Average mineral percentages for deposits found in the basin and flood plain of the Kansas River and its tributaries here named.

No. of samples used		100% light mineral fraction 1	2	3	4	100% heavy mineral fraction 5	6	7	8	9	10
	This thesis										
40	1951 flood	67	18	14	1*	19	43	7	5	4	21
8	1951 Blue River flood	71	18	11	0	20	42	7	3	4	24
	Seiler's thesis										
7	1950 flood***	64	15	21	0	13	35	9	12	4	27
7	1935 flood	23	67	8	2	9	31	39	5	1	15
28	"Post volcanic ash" (age period)	55	22	20	3	17	36	23	11	4	9
28	"Volcanic ash" (age period)	25	32	7	36	6	12	75	3	1	3
	"Volcanic ash" (recalculated)**	38	49	10	1	10	36	25	9	3	9
28	"Pre-volcanic ash" (age period)	44	38	12	6	15	32	34	9	2	8
2	Wamego terraces (average)	50	35	15	0	26	11	32	13	3	12
2	Zeandale terrace	65	25	10	1	50	3	21	5	4	17
1	Porch dust	47	28	20	5	6	25	38	7	1	23
5	Saline River	66	22	13	1	31	23	13	8	3	22
5	Solomon River	49	26	21	3	17	34	27	9	1	12
5	Salt Creek	57	33	7	1	42	21	15	4	1	17
	Harned's thesis										
8	Upland non-residual	70	22	8	0	26	31	10	14	3	16
4	Kaw Valley terrace mantle	53	38	9	0	22	26	11	13	4	19
20	Kaw River alluvium	69	19	12	0	30	34	6	15	5	10
40	Permian shale mantle	16	75	9	0	27	10	24	5	3	27
10	Smokey Hill River alluvium	45	46	9	0	26	36	14	8	2	9
10	Republican River alluvium	48	32	11	9	8	32	39	8	3	8
6	Glacial drift (stratified)	59	22	19	0	39	21	4	10	5	20
4	Glacial till	71	18	9	0	32	16	10	17	7	18

* Less than. ** Explained on page 57. *** Highwater stage only.

KEY: 1. Quartz; 2. Chalcedony; 3. Feldspars; 4. Volcanic ash; 5. Opaques; 6. Amphiboles and pyroxenes; 7. Muscovite and biotite; 8. Epidote; 9. Garnet; 10. Remaining minerals.

1951 flood sediments to past flood material of the Kaw, its tributaries, and contributing basin deposits. The sediments deposited by a river should come from nearly the same places year after year, tributaries and surface being the same. Therefore, a river's deposits should show the same mineral characteristics with only a few exceptions. These exceptions are caused by hydraulic action, difference in size, shape, and specific gravity of the material, time of deposition in relation to velocity (increasing or decreasing) of the stream, and the amount and location of runoff due to distant or local rainfall. These differences are local and seem to have little effect on the overall averages.

A study of the sample areas of the 1951 flood shows that several of the samples varied greatly in the same area, mineralogically. Also each area showed local variations. The Ogden area showed a 9 point high in opaques (28 percent), however, the average of opaques, amphiboles, and pyroxenes for the Ogden area was only 5 points above the whole 1951 flood average (Table 7). One unusual thing that stands out in the Ogden sample area alone is the ratio of magnetite to ilmenite (two to one). As no literature on the Kaw River gave a mineral separation of opaques, a comparison could not be made. The high percentage of opaques in the Ogden area was due to the river cutting a new channel and leaving an oxbow. This acted as a settling basin for placer-type minerals.

The Hunter's Island samples showed averages very much like the 1951 flood fractions, with the exception of a slight rise in mica and ash. Three samples from the 1951 flood showed such extreme mineral characteristics that they were dropped from the averages. Two of these samples were from the Hunter's Island area. One (sample 29) was a placer deposit which showed 53 percent opaques. A placer deposit is formed by the settling out of the heavy minerals due to a partial loss in gradient or velocity in the stream at the point of deposition. As only a part of the stream-carrying power is lost, the lighter minerals are carried on down stream.

The other samples dropped from the averages were silt deposits. Silt deposits are formed by a great loss in velocity and are characterized by a large proportion of light fraction to the heavy fraction and an increase in ash and mica. Ash, because of its light characteristic tends to settle in larger quantities in these silt deposits than elsewhere in the stream. Because of its platy character, micas tend to settle out with the light fraction. When the separation in bromoform is made, the mica separates with the heavy fraction which is usually relatively small in a silt deposit. Therefore, the mica percentage represents approximately half of the heavy fraction, where the same amount of mica placed in an average heavy fraction would only cause slight change in the mica percentage.

The use of sample 29 would have given the Hunter's Island area an opaque average of 20 percent instead of 12 percent. This one sample would have raised the whole average of the 40 samples taken in the 1951 flood from 19 percent to 20 percent opaques. By itself this would not be too far out of proportion and would give better balance to the average opaques in the Hunter's Island area.

A study of Harned's work on the 1940 Kaw River alluvium showed the samples used for that work to be taken from half placer and half non-placer deposits. Also no samples were discarded.

The use of the silt deposits in this thesis would have raised the average mica percentage from 6 to 11 percent in the Hunter's Island area, and from 9 to 12 percent in the Manhattan area. It was thought best not to let any one sample reflect so heavily. Therefore, samples 29, 36, and 14 were dropped from the percentages.

The Wild Cat Creek area (Table 3) showed slight increases in opaques, garnets, mica, and a 9-point drop in amphiboles and pyroxenes in the heavy fraction and a 9-point rise in chalcedony in the light fraction. These increases coupled with the lack of any ash in the samples indicates some influence of glacial origin or possibly the incorporation of terrace deposits with the 1951 flood deposits in this area. The similarities between the Wild Cat Creek samples and the upland non-residual mantle, Wamego, and Kaw River terrace deposits (Table 8) are great. It will be noted that the incorporation of this outside material does not affect the total 1951 flood averages to any great extent.

The hydraulic action of the water in an area will cause large differences of percentage for some minerals in different samples. The results are minor, as the differences seem to counteract themselves, if enough samples are taken. This is shown best in samples 22 and 26. Sample 22 showed 31 percent zircon and 21 percent opaques. Sample 26 showed 1 percent zircon and 38 percent opaques. As both minerals react much alike, it is rather odd that they should separate in this manner. When the two samples were added together a more normal trend is seen. The opaques are still a little high with 30 percent and the zircon is about normal with 16 percent. On a lesser scale these oddities of current, hydraulic action, and stream velocity are quite evident, but they have little or no control over the final averages as reported in this work.

The Manhattan area (Table 4) showed a 10-point drop in opaques and the highest pyroxenes and amphiboles percentage of the 1951 deposits (47 percent). This was only about a 3-point increase over the Hunter's Island area deposits and was thought to be due to the swift current between K-Hill and Bluemont Hill. The swift current did not allow the heavier opaques to settle out in the Manhattan area at least until the later stages of the flood. The drop in opaques caused a rise in pyroxenes and amphiboles, and the Blue River area showed the effect of this with a rise in opaques (20 percent) due to the wider valley and loss of stream gradient.

The current slackened quite rapidly near the end of the flood as shown by the increase in silt, ash, and mica in the deposite of the area. This was shown even more where two samples were taken from the same deposit. The sample nearest the surface always showed more silt, ash, and mica than the sample taken at depth.

Several samples were taken at different depths to see if time or deposition would show a difference in composition. Sample 27_a showed little relationship to its deeper sample 27_b, but it was a near duplicate to another upper sample (30_a). There was little difference in the a and b samples of number 30. Sample 28_a showed fair similarity in the heavy fraction, but the light fraction showed little likeness with sample 28_b.

Samples 29_a and b showed good similarity on both levels with no more than 1 percent difference in any mineral, heavy or light fraction, with the exception of a 6-point difference in mica.

Sample plots 28 and 30 were close together and sample plot 29 was some distance away from them. This shows that at one spot there was little change in type of material deposited and at another spot the time of deposition and velocity of the stream did make a difference. If a sample of flood sediments could have been taken at different times and places during the actual flood stage, and during the recession of the river, it would have helped greatly. It is a thing that will have to be done to better our understanding of floods in the future.

The Blue River area showed an increase in opaques as mentioned in the discussion of the Manhattan area. The similarity of this area to the Manhattan area or to the grant total of the 1951 flood is probably due to the fact that this material can be said to be back wash from the flooding Kaw River. The Blue River was not flooding, and the only sign of Blue River material was minor amounts of unweathered minerals found in the area that were not found elsewhere. No literature was found on the Blue River itself. The type of source material that forms the Blue River alluvium would be almost entirely glacial, because of the stream's north-south direction through glacial sediments. The fact that the Blue River was not flooding and the similarity of the samples near the mouth of the Blue River area to the rest of the 1951 flood deposits show that the sediments found at the mouth of the Blue River were back wash from the Kaw, and that the Blue River contributed very little to the 1951 flood deposits.

A Study of Source Materials and Their Relationship to the 1951 Flood

In order to determine the origin of the 1951 flood deposits, a study was made of all material available that could influence directly or indirectly the mineral composition of the Kaw River.

Reports on the following materials were studied: Kaw River alluvium (1940), 1935 flood, 1950 high water stage, and the Kaw River sediments at depth; terrace deposits of the Kaw, upland non-residual material, glacial till, non-stratified drift, Permian shale mantle, dust from a porch; Republican, Smokey Hill, Saline, and Solomon Rivers, and Salt Creek.

The alluvial material (Harned, 5) showed the nearest relationship to the 1951 flood deposits. There were no percentage differences greater than 3 points in either the heavy or light fractions with one exception. The 1951 flood showed more than 9 percent amphiboles and pyroxenes and less than 11 percent opaques. The sum of the two like minerals, however, showed only a 2-point difference.

The 1950 high water deposits (Seiler, 17) showed good similarity to the 1951 flood deposits. The light fraction showed a little less feldspar, and the heavy fraction showed some slight differences in opaques and pyroxenes and amphiboles. The size of the 1951 flood in relation to the 1950 high water stage could account for this, and the 1950 channel flood would contain only channel material, while the 1951 flood could incorporate larger amounts of outside material.

The 1950 channel flood (Seiler, 17) showed more epidotes and less opaques, pyroxenes, and amphiboles.

Seiler separated the lenses of the Kaw River alluvium into three zones. The top zone he called the post volcanic ash zone. This alluvium showed a fair similarity to the 1950 flood deposits and may have contributed in a small way to the 1950 flood. This alluvial deposit of the post volcanic ash age showed 3 points ash and 12 points less quartz in the light fraction, and three times the amount of mica in the heavy fraction. The heavy fraction showed a closer similarity to the 1950 channel flood which is to be expected, but mica and ash were still too high for Seiler's post volcanic age material to have been a large contributing factor. The middle layer of alluvial material showed very little relationship, with more chalcedony than quartz and 36 percent volcanic ash, while the heavy fraction showed 10 points less opaques, and 10 times the mica. The bottom zone showed about the same relationship as the volcanic ash zone with two exceptions, which were less ash and only 5 times more mica.

The age periods designated post volcanic ash, volcanic ash, and pre-volcanic ash (Seiler, 17) formed the upper 12 to 24 feet of the Kaw River flood plain and show only slight similarity to the 1951 flood deposits. The indication is that the present material (1951 flood deposits) did not come from depth in any great quantity.

The 1935 flood deposits were quite different from other Kaw River flood deposits and showed unusual percentages in both heavy and light fraction, but the heavy fraction is very similar to the heavy fraction of the silt deposits from the 1951 flood. As the 1935 flood deposits were silt deposits, this should be true. The light fraction is quite different due to the large amounts of chalcedony (67 percent). With the exception of the Permian shale (75 percent chalcedony) and the terraces of the Kaw (38 percent) this characteristic is not found in other studied sediments. This could have been deposited by solution and suspension from such source beds as these, but it is more likely that percolating waters formed the large amounts of chalcedony in place in the flood plain before the flood reworked the channel.

In all cases the ash and mica are quite high, while opaques, amphiboles and pyroxenes, and garnet were quite low.

Terrace deposits of the Kaw River, having been deposited by the river, should show fair relationship to sediments in the river at present, and they do. In Table 8 this relationship is shown. The Wamego terrace shows the least resemblance, because of the large amount of glacial material it contained.

Table 8. Average mineral percentages of known silt deposits in relation to the 1935 flood.

Mineral	1935 flood	Dust on porch	Permian shale mantle	Silt deposit from 1951 flood
Light fraction				
Chalcedony	67	28	75	19
Quartz	35	47	16	64
Feldspars	8	20	9	12
Ash	2	5	0	5
Heavy fraction				
Opaques	9) 40	6) 31	27) 37	6) 45
Amphiboles and pyroxenes	31)	25)	10)	39)
Mica	39	38	24	42
Epidote	5	7	5	2
Garnet	1	1	3	2
Others	15	23	27	9

Other Kaw River terraces showed a fair relationship to the 1951 flood and to the Wild Cat Creek area in particular. It is quite possible that terrace material may have influenced the Wild Cat Creek area considerably, as shown by their respective percentages in Table 8.

The material from the Zeandale terrace showed the light fraction to be quite similar to the Kaw alluvium deposits. The 50 percent opaques in the heavy fraction showed that the terrace included some placer materials, however. This high percentage of opaques is caused indirectly by glaciation. The glacier terminated near the mouth of the Blue River, and excessive washings by melt water and Blue River floods perhaps left the semi-placer materials that are part of the terrace.

The upland non-residual material has a very great influence on the type of material carried into the Kaw River flood plain from the uplands. In some respects it is more like the 1951 flood deposits than any other material studied. The overall relationship, as shown by Table 9, is very good and it must be considered as a parent material, if not a direct source material.

Table 9. Kaw River terraces in relation to the 1951 flood.

Area	Light fraction				Heavy fraction					
	Qtz.	Chal.	Feld.	Ash	Op.	Am. & Py.	Mica	Epid.	Gar.	Others
Wild Cat (1951 flood)	62	26	11	0	23	60 37	9	4	6	21
Kaw River terraces	53	38	9	0	22	48 26	11	13	4	19
Wamego terraces	50	35	15	0	26	37 11	32	13	3	12

Stratified drift shows a very good relationship in the heavy fraction, but there is too much feldspar, and not enough quartz in the light fraction. The light fraction of the Glacial Till shows a good relationship to the 1951 flood deposits, but the heavy fraction is too low in pyroxenes and amphiboles. Therefore, it is believed that the drift and Till deposits have in the past and will continue to contribute to the Kaw River alluvium as a parent material, but they will influence the actual flood sediments only indirectly.

The alluvium of the tributaries of the Kaw River showed little relationship to the 1951 flood materials, even though some of these were flooding at the same time as the area studied.

Table 10. Source materials of the Kaw in relation to the 1951 flood deposits.

	Light fraction				Heavy fraction					
Area	Qtz.	Chal.	Feld.	Ash	Op.	Am. & Py.	Mica	Epid.	Gar.	Others
						62				
1951 flood	67	18	14	0	19	43	7	5	4	21
						57				
Upland non-residual	70	22	8	0	26	31	11	13	4	19
						60				
Non-stratified drift	59	22	19	0	39	21	4	10	5	20
						48				
Glacial till	71	18	9	0	32	16	10	17	7	18

The Republican River alluvium showed little similarity to the 1951 flood deposits of the Kaw. The low quartz, high ash and chalcedony in the light fraction, and the very low opaques and high mica percentages show without doubt the Republican River did not contribute much to the 1951 flood deposits. Alluvial material from the Saline River showed a fair resemblance to the 1951 flood deposits. The best resemblance was in the light fraction, but the pyroxenes and amphiboles of the heavy fraction were far too low to show any close relationship.

The Solomon River showed the best relationship of all the tributaries. The light fraction, however, was low in quartz and high in ash, chalcedony, and feldspars and gave no resemblance whatever to the 1951 flood deposits studied. The heavy fraction was low in amphiboles and pyroxenes and garnet and far too high in mica.

The tributary that showed the poorest resemblance to the 1951 Kaw flood deposits was Salt Creek. The light fraction showed the quartz and feldspars to be a little low and the chalcedony far too high. The heavy fraction had twice too much mica and not enough garnet. The combined opaques and pyroxenes and amphiboles had about the right percentage, but they were reversed in comparison to the 1951 flood deposits. The opaques and chalcedony would tend to show a much more weathered and older origin than the sediments of the 1951 Kaw River flood.

Table 11. Study of the Kaw tributaries in relation to the 1951 flood.

	Light fraction				Heavy fraction						
River	Qtz.	Chal.	Feld.	Ash	Op.		Am. & Py.	Mica	Epid.	Gar.	Others
1951 Kaw flood	67	18	14	1	19	62	43	7	5	4	21
Republican	48	32	11	9	8	40	32	39	8	3	8
Saline	65	21	13	1	31	54	23	13	9	3	22
Solomon	49	26	21	3	17	51	34	27	4	1	12
Salt Creek	59	33	7	1	42	63	21	15	4	1	17

SUMMARY OF CONCLUSIONS

In an attempt to arrive at some conclusions as to the origin of the 1951 flood sediments, all available material from the basin, tributaries, and alluvium of the Kaw River was studied.

The large percentages of unstable minerals such as amphiboles and pyroxenes, epidote, and garnet point to a parent material of glacial origin in part. The mineral composition of drift, till, and especially upland non-residual material were found to be very similar to the 1951 flood.

The particle size, difference in mineral percentage, and type of secondary mineral found in the tributaries of the Kaw River on comparison with the 1951 flood deposits seem to show that these contributed very little to the 1951 flood, even though these streams were at flood stage.

The terraces of the Kaw should show some relationship to the alluvial material found in the flood plane of the river. A study of the terrace sediments helps to form a better picture of what a normal sediment of the Kaw should be, because they were deposited by the Kaw in times past. Only where a large flood might happen to cut into an old terrace would terrace sediments influence the flood sediments. This would be a local thing such as might have happened in the Wild Cat Creek area of the 1951 flood.

The nearest relationship to the 1951 flood were found to be past floods of the Kaw and alluvium from the Kaw. A comparison of Seiler's ash ages of the Kaw River flood plain to the 1951 flood sediments show that the 1951 flood samples did not come from any great depth in the flood plain, but are related to Seiler's post-volcanic ash zone.

These factors indicate that much of the material in a flood must be of relatively local origin with deposition and channel erosion occurring at the same time.

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PETROLOGY OF THE 1951 KAW RIVER FLOOD DEPOSITS BETWEEN OGDEN AND MANHATTAN, KANSAS

by

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During the research, 40 samples were collected along the channel of the Kansas River. The samples were taken with the idea of obtaining the widest distribution of alluvium that could be positively identified as deposition due to the 1951 flood.

The samples were dried, weighed, and then dispersed in a mechanical shaker. After shaking, each sample was sieved to save the grain size best suited for mineralogical study under a petrographic microscope. Iron stains and calcium carbonate were removed by boiling the sample for five minutes in hydrochloric acid. Next, the samples were washed free of acid and dried for specific gravity separation in bromoform. Bromoform has a specific gravity of approximately 2.89 and all minerals with a lower specific gravity floated while the minerals with a higher specific gravity sank. The minerals that floated on bromoform were called light minerals and consisted of the following: quartz, feldspars, chalcedony, and volcanic ash. Ilmenite, hornblende, zircon, epidote, muscovite, biotite, garnet, tourmaline, titanite, and hypersthene are heavier than bromoform and sank in the liquid.

After the minerals had been separated, a microscopic slide of the light and heavy minerals of each sample was made. Canada balsam was used as a mounting medium. A minimum of 100 grains was counted and identified on the microscopic slides with the aid of the petrographic microscope. Percentages of the minerals in the slides were calculated for use in comparing the 1951 flood material with its possible sources.

The 1951 sediments of the Kansas River showed very little relationship to the sediments in its tributaries, in size, or mineral percentage. The Kaw terraces showed some relationship to the flood sediments, and as the terraces are old river deposits, they should. The Kaw terraces influenced the 1951 flood deposits only locally where the current cut into a terrace. The 1951 flood sediments were very similar to the past flood sediments of the Kaw and the alluvium of the Kaw flood plain. A comparison of the 1951 flood and Seiler's ash ages showed a relationship to the post-volcanic ash age zone only, and therefore indicated that the sediments of the 1951 flood were not due to erosion of alluvium to any great depth.

This research indicates that much of the materials in the Kaw River flood plain are of relatively local origin with deposition and channel erosion occurring at nearly the same time, and that with the possible exception of the finest silt and the clay, sediments are not carried any great distance at one time.